KEY CONCEPT

1.2 Matter is made of atoms.

BEFORE, you learned

- Matter has mass
- Matter has volume

NOW, you will learn

- About the smallest particles of matter
- How atoms combine into molecules
- How atoms and molecules move

VOCABULARY

atom p. 16
molecule p. 18

THINK ABOUT

How small is an atom?

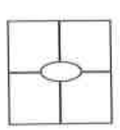
All matter is made up of very tiny particles called atoms. It is hard to imagine exactly how small these particles are. Suppose that each of the particles making up the pin shown in the photograph on the right were actually the size of the round head on the pin. How large would the pin be in that case? If you could stick such a pin in the ground, it would cover about 90 square miles—about one-seventh the area of London, England. It would also be about 80 miles high—almost 15 times the height of Mount Everest.

Atoms are extremely small.

How small can things get? If you break a stone wall into smaller and smaller pieces, you would have a pile of smaller stones. If you could break the smaller stones into the smallest pieces possible, you would have a pile of atoms. An **atom** is the smallest basic unit of matter.

The idea that all matter is made of extremely tiny particles dates back to the fifth century B.C., when Greek philosophers proposed the first atomic theory of matter. All matter, they said, was made of only a few different types of tiny particles called atoms. The different arrangements of atoms explained the differences among the substances that make up the world. Although the modern view of the atom is different from the ancient view, the idea of atoms as basic building blocks has been confirmed. Today scientists have identified more than 100 different types of atoms.

VOCABULARY
Make a four square diagram for *atom* that includes details that will help you remember the term.



CHECK YOUR READING What are atoms? How are they like building blocks?

Atoms

It is hard to imagine that visible matter is composed of particles too tiny to see. Although you cannot see an individual atom, you are constantly seeing large collections of them. You are a collection of atoms. So are your textbook, a desk, and all the other matter around you. Matter is not something that contains atoms; matter is atoms. A desk, for example, is a collection of atoms and the empty space between those atoms. Without the atoms, there would be no desk—just empty space.

Atoms are so small that they cannot be seen even with very strong optical microscopes. Try to imagine the size of an atom by considering that a single teaspoonful of water contains approximately 500,000,000,000,000,000,000,000 atoms. Although atoms are extremely small, they do have a mass. The mass of a single teaspoonful of water is about 5 grams. This mass is equal to the mass of all the atoms that the water is made of added together.

READING TIP
The word *atom* comes from the Greek word *atomos,* meaning "indivisible," or "cannot be divided."

INVESTIGATE Mass

How do you measure the mass of an atom?

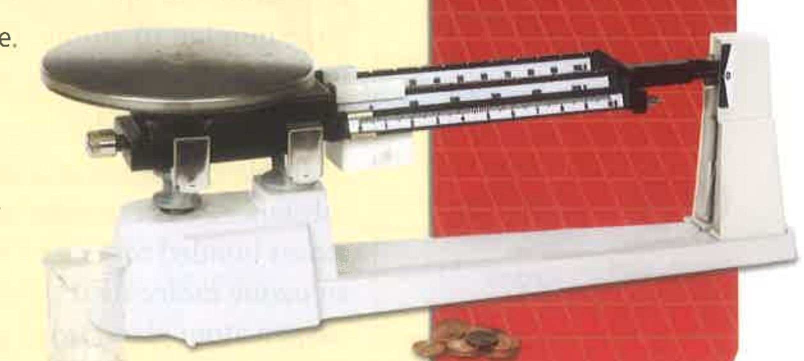
PROCEDURE

1. Find the mass of the empty beaker. Record your result.
2. Place 10 pennies into the beaker. Find the mass of the beaker with the pennies in it. Record your result.
3. Subtract the mass of the empty beaker from the mass of the beaker with the pennies. Record your result.
4. Divide the difference in mass by 10. Record your result.

WHAT DO YOU THINK?

- What is the mass of one penny? What assumptions do you make when you answer this question?
- How might scientists use a similar process to find the mass of a single atom?

CHALLENGE All pennies may not be the same. After years of use, some pennies may have had some of their metal rubbed away. Also, the materials that make up pennies have changed. Find the individual mass of several pennies and compare the masses. Do all pennies have exactly the same mass?



SKILL FOCUS
Modeling

MATERIALS
- beam balance
- beaker
- 10 pennies

TIME
20 minutes

Molecules

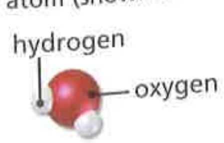
When two or more atoms bond together, or combine, they make a particle called a **molecule.** A molecule can be made of atoms that are different or atoms that are alike. A molecule of water, for example, is a combination of different atoms—two hydrogen atoms and one oxygen atom (also written as H_2O). Hydrogen gas molecules are made of the same atom—two hydrogen atoms bonded together.

A molecule is the smallest amount of a substance made of combined atoms that is considered to be that substance. Think about what would happen if you tried to divide water to find its smallest part. Ultimately you would reach a single molecule of water. What would you have if you divided this molecule into its individual atoms of hydrogen and oxygen? If you break up a water molecule, it is no longer water. Instead, you would have hydrogen and oxygen, two different substances.

READING TIP Not all atoms and molecules have color. In this book atoms and molecules are given colors to make them easier to identify.

CHECK YOUR READING How is a molecule related to an atom?

The droplets of water in this spider web are made of water molecules. Each molecule contains two hydrogen atoms (shown in white) and one oxygen atom (shown in red).



water

Molecules can be made up of different numbers of atoms. For example, carbon monoxide is a molecule that is composed of one carbon atom and one oxygen atom. Molecules also can be composed of a large number of atoms. The most common type of vitamin E molecule, for example, contains 29 carbon atoms, 50 hydrogen atoms, and 2 oxygen atoms.

Molecules made of different numbers of the same atom are different substances. For example, an oxygen gas molecule is made of two oxygen atoms bonded together. Ozone is also composed of oxygen atoms, but an ozone molecule is three oxygen atoms bonded together. The extra oxygen atom gives ozone properties that are different from those of oxygen gas.

oxygen ozone

This photograph shows the interior of Grand Central Terminal in New York City. Light from the window reflects off dust particles that are being moved by the motion of the molecules in air.

Atoms and molecules are always in motion.

If you have ever looked at a bright beam of sunlight, you may have seen dust particles floating in the air. If you were to watch carefully, you might notice that the dust does not fall toward the floor but instead seems to dart about in all different directions. Molecules in air are constantly moving and hitting the dust particles. Because the molecules are moving in many directions, they collide with the dust particles from different directions. This action causes the darting motion of the dust that you observe.

Atoms and molecules are always in motion. Sometimes this motion is easy to observe, such as when you see evidence of molecules in air bouncing dust particles around. Water molecules move too. When you place a drop of food coloring into water, the motion of the water molecules eventually causes the food coloring to spread throughout the water.

The motion of individual atoms and molecules is hard to observe in solid objects, such as a table. The atoms and molecules in a table cannot move about freely like the ones in water and air. However, the atoms and molecules in a table are constantly moving—by shaking back and forth, or by twisting—even if they stay in the same place.

1.2 Review

KEY CONCEPTS

1. What are atoms?
2. What is the smallest particle of a substance that is still considered to be that substance?
3. Why do dust particles in the air appear to be moving in different directions?

CRITICAL THINKING

4. **Apply** How does tea flavor spread from a tea bag throughout a cup of hot water?
5. **Infer** If a water molecule (H_2O) has two hydrogen atoms and one oxygen atom, how would you describe the makeup of a carbon dioxide molecule (CO_2)?

CHALLENGE

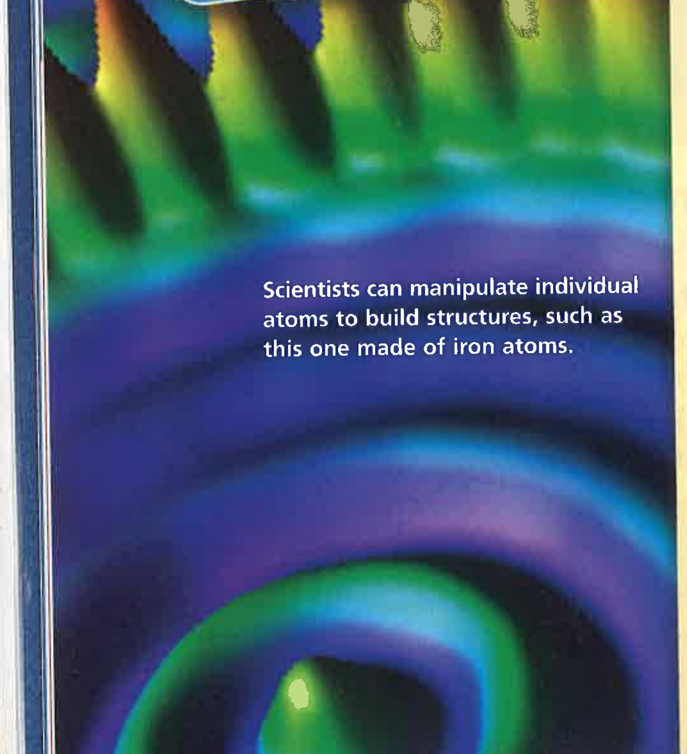
6. **Synthesize** Assume that a water balloon has the same number of water molecules as a helium balloon has helium atoms. If the mass of the water is 4.5 times greater than the mass of the helium, how does the mass of a water molecule compare with the mass of a helium atom?

EXTREME SCIENCE

LOOKING AT ATOMS

Particles Too Small to See

Atoms are so small that you cannot see them through an ordinary microscope. In fact, millions of them could fit in the period at the end of this sentence. Scientists can make images of atoms, however, using an instrument called a scanning tunneling microscope (STM).



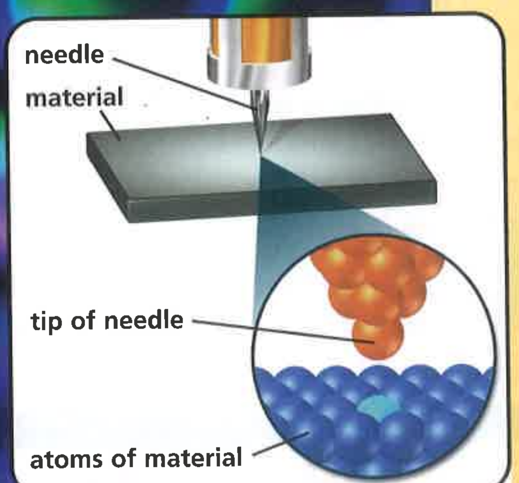
Scientists can manipulate individual atoms to build structures, such as this one made of iron atoms.

Bumps on a Surface

The needle of the scanning tunneling microscope has a very sharp tip that is only one atom wide. The tip is brought close to the surface of the material being observed, and an electric current is applied to the tip. The microscope measures the interaction between the electrically charged needle tip and the nearest atom on the surface of the material. An image of the surface is created by moving the needle just above the surface. The image appears as a series of bumps that shows where the atoms are located. The result is similar to a contour map.

Tiny Pieces of Matter

- Images of atoms did not exist until 1970.
- Atoms are so small that a single raindrop contains more than 500 billion trillion atoms.
- If each atom were the size of a pea, your fingerprint would be larger than Alaska.
- In the space between stars, matter is so spread out that a volume of one liter contains only about 1000 atoms.



An STM maps the position of atoms using a needle with a tip that is one atom wide.

Moving Atoms

Scientists also can use the tip of the STM needle to move atoms on a surface. The large image at left is an STM image of a structure made by pushing individual atoms into place on a very smooth metal surface. This structure was designed as a corral to trap individual atoms inside.

EXPLORE

1. **INFER** Why must the tip of a scanning tunneling microscope be only one atom wide to make an image of atoms on a surface?
2. **CHALLENGE** Find out more about images of atoms on the Internet. How are STM images used in research to design better materials?

RESOURCE CENTER
CLASSZONE.COM
Find more images from scanning tunneling microscopes.

KEY CONCEPT

1.3 Matter combines to form different substances.

BEFORE, you learned

- Matter is made of tiny particles called atoms
- Atoms combine to form molecules

NOW, you will learn

- How pure matter and mixed matter are different
- How atoms and elements are related
- How atoms form compounds

VOCABULARY

element p. 22
compound p. 23
mixture p. 23

EXPLORE Mixed Substances

What happens when substances are mixed?

PROCEDURE

1. Observe and describe a teaspoon of cornstarch and a teaspoon of water.
2. Mix the two substances together in the cup. Observe and describe the result.

WHAT DO YOU THINK?

- After you mixed the substances, could you still see each substance?
- How was the new substance different from the original substances?

MATERIALS

- cornstarch
- water
- small cup
- spoon

MAIN IDEA AND DETAILS
Continue to organize your notes in a two-column chart as you read.

Matter can be pure or mixed.

Matter can be pure, or it can be two or more substances mixed together. Most of the substances you see around you are mixed, although you can't always tell that by looking at them. For example, the air you breathe is a combination of several substances. Wood, paper, steel, and lemonade are all mixed substances.

You might think that the water that you drink from a bottle or from the tap is a pure substance. However, drinking water has minerals dissolved in it and chemicals added to it that you cannot see. Often the difference between pure and mixed substances is apparent only on the atomic or molecular level.

A pure substance has only one type of component. For example, pure water contains only water molecules. Pure silver contains only silver atoms. Coins and jewelry that look like silver are often made of silver in combination with other metals.

REMINDER

A molecule consists of two or more atoms that are bonded together.

If you could look at the atoms in a bar of pure gold, you would find only gold atoms. If you looked at the atoms in a container of pure water, you would find water molecules, which are a combination of hydrogen and oxygen atoms. Does the presence of two types of atoms mean that water is not really a pure substance after all?

A substance is considered pure if it contains only a single type of atom, such as gold, or a single combination of atoms that are bonded together, such as a water molecule. Because the hydrogen and oxygen atoms are bonded together as molecules, water that has nothing else in it is considered a pure substance.

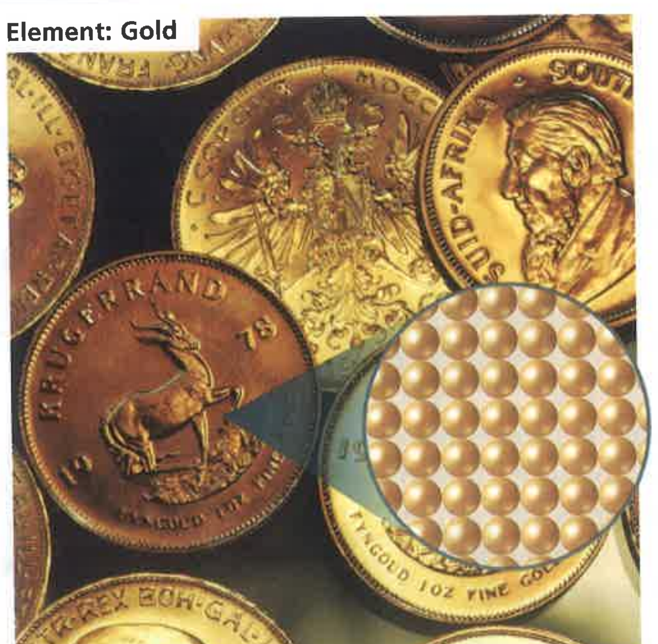
Elements

One type of pure substance is an element. An **element** is a substance that contains only a single type of atom. The number of atoms is not important as long as all the atoms are of the same type. You cannot separate an element into other substances.

You are probably familiar with many elements, such as silver, oxygen, hydrogen, helium, and aluminum. There are as many elements as there are types of atoms—more than 100. You can see the orderly arrangement of atoms in the element gold, on the left below.

CHECK YOUR READING Why is an element considered to be a pure substance?

Element: Gold



The atoms in gold are all the same type of atom. Therefore, gold is an element.

Compound: Dry Ice

Dry ice is frozen carbon dioxide, a compound. Each molecule is made of one carbon atom and two oxygen atoms.

Compounds

A **compound** is a substance that consists of two or more different types of atoms bonded together. A large variety of substances can be made by combining different types of atoms to make different compounds. Some types of compounds are made of molecules, such as water and carbon dioxide, shown on page 22. Other compounds are made of atoms that are bonded together in a different way. Table salt is an example.

A compound can have very different properties from the individual elements that make up that compound. Pure table salt is a common compound that is a combination of sodium and chlorine. Although table salt is safe to eat, the individual elements that go into making it—sodium and chlorine—are poisonous.

CHECK YOUR READING What is the relationship between atoms and a compound?

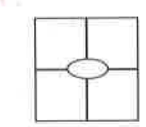
Mixtures

Most of the matter around you is a mixture of different substances. Seawater, for instance, contains water, salt, and other minerals mixed together. Your blood is a mixture of blood cells and plasma. Plasma is also a mixture, made up of water, sugar, fat, protein, salts, and minerals.

A **mixture** is a combination of different substances that remain the same individual substances and can be separated by physical means. For example, if you mix apples, oranges, and bananas to make a fruit salad, you do not change the different fruits into a new kind of fruit. Mixtures do not always contain the same amount of the various substances. For example, depending on how the salad is made, the amount of each type of fruit it contains will vary.

VOCABULARY

Remember to make a four square diagram for *mixture* in your notebook.



APPLY In what ways can a city population be considered a mixture?

INVESTIGATE Mixtures

How well do oil and water mix?

SKILL FOCUS
Inferring

MATERIALS
- food coloring
- beaker of water
- jar with lid
- vegetable oil

for Challenge:
- dish soap

TIME
20 minutes

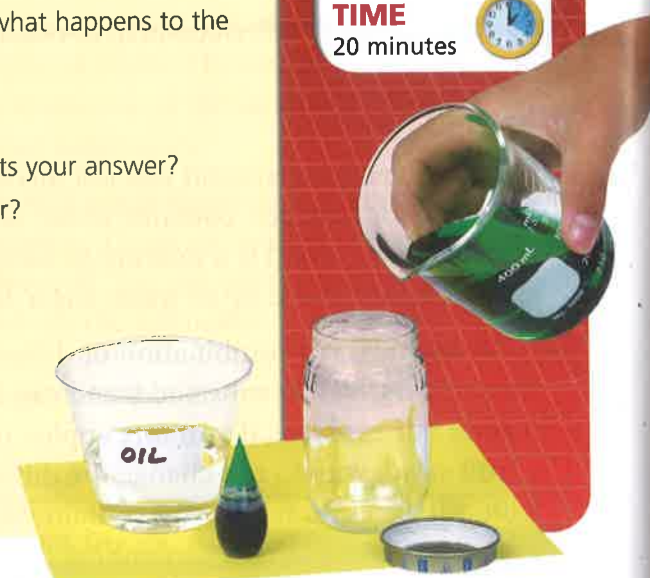
PROCEDURE

1. Add a few drops of food coloring to the water in the beaker. Swirl the water around in the beaker until the water is evenly colored throughout.
2. Pour the colored water from the beaker into the jar until the jar is about one-fourth full.
3. Add the same amount of vegetable oil to the jar. Screw the lid tightly on the jar.
4. Carefully shake the jar several times with your hand over the cover, and then set it on the table. Observe and record what happens to the liquids in the jar.
5. Turn the jar upside down and hold it that way. Observe what happens to the liquids and record your observations.

WHAT DO YOU THINK?

- Does water mix with food coloring? What evidence supports your answer?
- Do water and oil mix? What evidence supports your answer?
- What happened when you turned the jar upside down?
- Based on your observations, what can you infer about the ability of different liquids to mix?

CHALLENGE To clean greasy dishes, you add soap to the dishwater. Try adding soap to your mixture. What does the soap do?



RESOURCE CENTER
CLASSZONE.COM
Find out more about mixtures.

Comparing Mixtures and Compounds

Although mixtures and compounds may seem similar, they are very different. Consider how mixtures and compounds compare with each other.

- The substances in mixtures remain the same substances. Compounds are new substances formed by atoms that bond together.
- Mixtures can be separated by physical means. Compounds can be separated only by breaking the bonds between atoms.
- The proportions of different substances in a mixture can vary throughout the mixture or from mixture to mixture. The proportions of different substances in a compound are fixed because the type and number of atoms that make up a basic unit of the compound are always the same.

CHECK YOUR READING How is a mixture different from a compound?

Parts of mixtures can be the same or different throughout.

It is obvious that something is a mixture when you can see the different substances in it. For example, if you scoop up a handful of soil, you might see that it contains dirt, small rocks, leaves, and even insects. You can separate the soil into its different parts.

Exactly what you see depends on what part of the soil you scoop up. One handful of soil might have more pebbles or insects in it than another handful would. There are many mixtures, such as soil, that have different properties in different areas of the mixture. Such a mixture is called a heterogeneous (HEHT-uhr-uh-JEE-nee-uhs) mixture.

In some types of mixtures, however, you cannot see the individual substances. For example, if you mix sugar into a cup of water and stir it well, the sugar seems to disappear. You can tell that the sugar is still there because the water tastes sweet, but you cannot see the sugar or easily separate it out again.

When substances are evenly spread throughout a mixture, you cannot tell one part of the mixture from another part. For instance, one drop of sugar water will be almost exactly like any other drop. Such a mixture is called a homogeneous (HOH-muh-JEE-nee-uhs) mixture. Homogenized milk is processed so that it becomes a homogeneous mixture of water and milk fat. Milk that has not been homogenized will separate—most of the milk fat will float to the top as cream while leaving the rest of the milk low in fat.

READING TIP
The prefix *hetero* means "different," and the prefix *homo* means "same." The Greek root *genos* means "kind."

1.3 Review

KEY CONCEPTS

1. What is the difference between pure and mixed matter?
2. How are atoms and elements related?
3. How are compounds different from mixtures?

CRITICAL THINKING

4. **Infer** What can you infer about the size of sugar particles that are dissolved in a mixture of sugar and water?
5. **Infer** Why is it easier to remove the ice cubes from cold lemonade than it is to remove the sugar?

CHALLENGE

6. **Apply** A unit of sulfuric acid is a molecule of 2 atoms of hydrogen, 1 atom of sulfur, and 4 atoms of oxygen. How many of each type of atom are there in 2 molecules of sulfuric acid?

MATH in SCIENCE

MATH TUTORIAL
CLASSZONE.COM
Click on Math Tutorial for more help with circle graphs.

SKILL: MAKING A CIRCLE GRAPH

A Mixture of Spices

Two different mixtures of spices may contain the exact same ingredients but have very different flavors. For example, a mixture of cumin, nutmeg, and ginger powder can be made using more cumin than ginger, or it can be made using more ginger than cumin.

One way to show how much of each substance a mixture contains is to use a circle graph. A circle graph is a visual way to show how a quantity is divided into different parts. A circle graph represents quantities as parts of a whole.

Example

Make a circle graph to represent a spice mixture that is 1/2 cumin, 1/3 nutmeg, and 1/6 ginger.

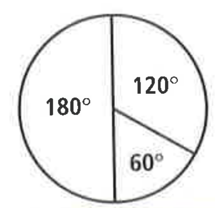
(1) To find the angle measure for each sector of the circle graph, multiply each fraction in your mixture by 360°.

Cumin: $\frac{1}{2} \cdot 360° = 180°$

Nutmeg: $\frac{1}{3} \cdot 360° = 120°$

Ginger: $\frac{1}{6} \cdot 360° = 60°$

(2) Use a compass to draw a circle. Use a protractor to draw the angle for each sector.



(3) Label each sector and give your graph a title.

ANSWER

Spice Mixture

Answer the following questions.

1. Draw a circle graph representing a spice mixture that is 1/2 ginger, 1/4 cumin, and 1/4 crushed red pepper.

2. A jeweler creates a ring that is 3/4 gold, 3/16 silver, and 1/16 copper. Draw a circle graph representing the mixture of metals in the ring.

3. Draw a circle graph representing a mixture that is 1/5 sand, 2/5 water, and 2/5 salt.

CHALLENGE Dry air is a mixture of about 78 percent nitrogen, 21 percent oxygen, and 1 percent other elements. Create a circle graph representing the elements found in air.

KEY CONCEPT

1.4

Matter exists in different physical states.

BEFORE, you learned
- Matter has mass
- Matter is made of atoms
- Atoms and molecules in matter are always moving

NOW, you will learn
- About the different states of matter
- How the different states of matter behave

VOCABULARY

states of matter p. 27
solid p. 28
liquid p. 28
gas p. 28

EXPLORE Solids and Liquids

How do solids and liquids compare?

PROCEDURE

1. Observe the water, ice, and marble. Pick them up and feel them. Can you change their shape? their volume?
2. Record your observations. Compare and contrast each object with the other two.

WHAT DO YOU THINK?
- How are the ice and the water in the cup similar? How are they different?
- How are the ice and the marble similar? How are they different?

MATERIALS
- water in a cup
- ice cube
- marble
- pie tin

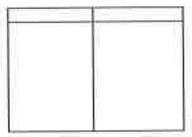
Particle arrangement and motion determine the state of matter.

When you put water in a freezer, the water freezes into a solid (ice). When you place an ice cube on a warm plate, the ice melts into liquid water again. If you leave the plate in the sun, the water becomes water vapor. Ice, water, and water vapor are made of exactly the same type of molecule—a molecule of two hydrogen atoms and one oxygen atom. What, then, makes them different?

Ice, water, and water vapor are different states of water. **States of matter** are the different forms in which matter can exist. The three familiar states are solid, liquid, and gas. When a substance changes from one state to another, the molecules in the substance do not change. However, the arrangement of the molecules does change, giving each state of matter its own characteristics.

Solid, liquid, and gas are common states of matter.

MAIN IDEA AND DETAILS Remember to organize your notes in a two-column chart as you read.



A substance can exist as a solid, a liquid, or a gas. The state of a substance depends on the space between its particles and on the way in which the particles move. The illustration on page 29 shows how particles are arranged in the three different states.

1. A **solid** is a substance that has a fixed volume and a fixed shape. In a solid, the particles are close together and usually form a regular pattern. Particles in a solid can vibrate but are fixed in one place. Because each particle is attached to several others, individual particles cannot move from one location to another, and the solid is rigid.
2. A **liquid** has a fixed volume but does not have a fixed shape. Liquids take on the shape of the container they are in. The particles in a liquid are attracted to one another and are close together. However, particles in a liquid are not fixed in place and can move from one place to another.
3. A **gas** has no fixed volume or shape. A gas can take on both the shape and the volume of a container. Gas particles are not close to one another and can move easily in any direction. There is much more space between gas particles than there is between particles in a liquid or a solid. The space between gas particles can increase or decrease with changes in temperature and pressure.

CHECK YOUR READING Describe two differences between a solid and a gas.

The particles in a solid are usually closer together than the particles in a liquid. For example, the particles in solid steel are closer together than the particles in molten—or melted—steel. However, water is an important exception. The molecules that make up ice actually have more space between them than the molecules in liquid water do.

The fact that the molecules in ice are farther apart than the molecules in liquid water has important consequences for life on Earth. Because there is more space between its molecules, ice floats on liquid water. By contrast, a piece of solid steel would not float in molten steel but would sink to the bottom.

Because ice floats, it remains on the surface of rivers and lakes when they freeze. The ice layer helps insulate the water and slow down the freezing process. Animals living in rivers and lakes can survive in the liquid water layer below the ice layer.

States of Matter

Matter can exist in different states. The state of matter depends on the arrangement and motion of the particles.

1 Solid

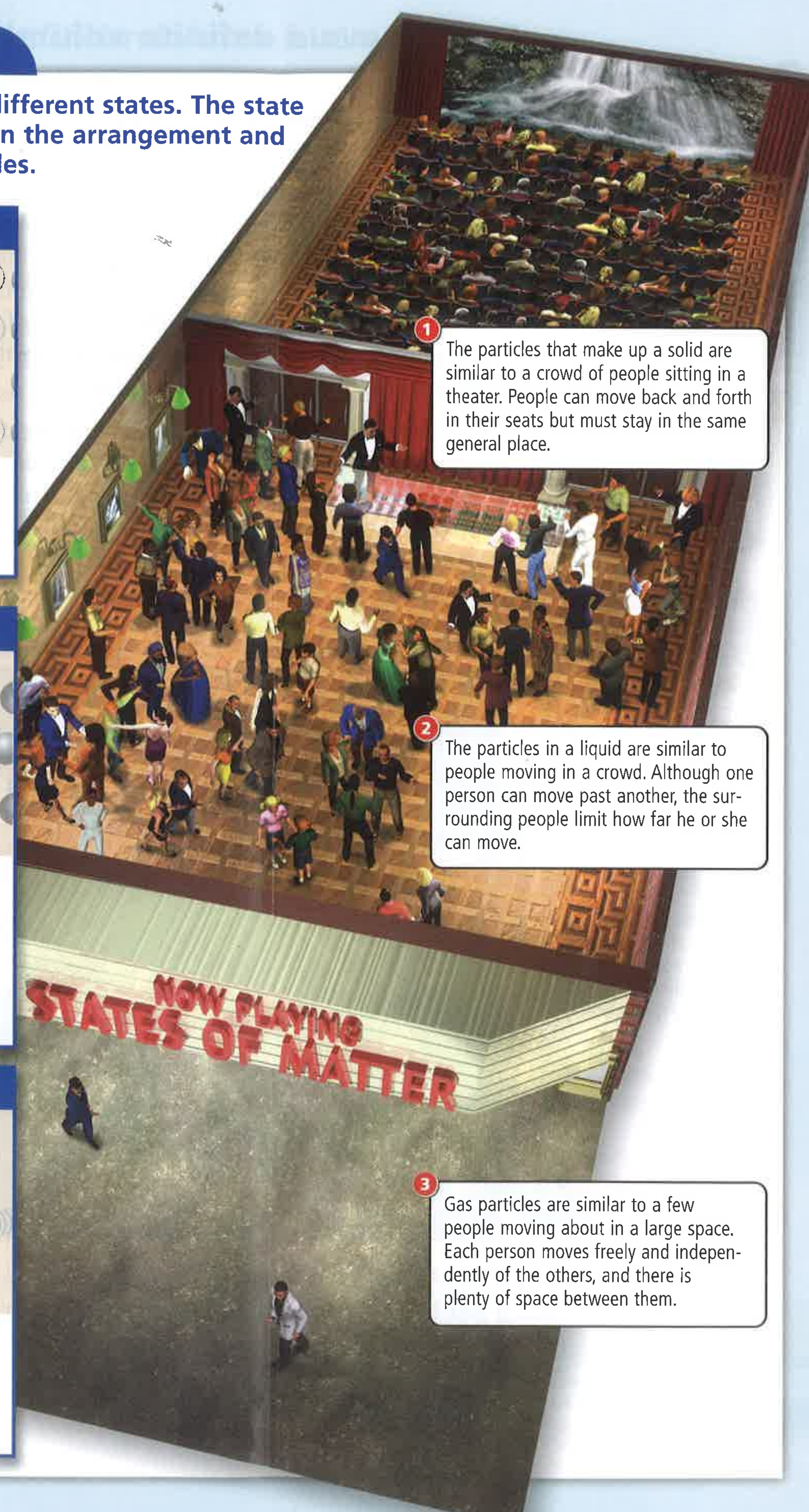
The particles in a solid are close together. They are fixed in place but can vibrate.

2 Liquid

The particles that make up a liquid are close together but usually farther apart than the particles in a solid are. They can slide freely past one another.

3 Gas

The particles in a gas are farther apart than particles in liquids and solids. Gas particles move freely in any direction.



1 The particles that make up a solid are similar to a crowd of people sitting in a theater. People can move back and forth in their seats but must stay in the same general place.

2 The particles in a liquid are similar to people moving in a crowd. Although one person can move past another, the surrounding people limit how far he or she can move.

3 Gas particles are similar to a few people moving about in a large space. Each person moves freely and independently of the others, and there is plenty of space between them.

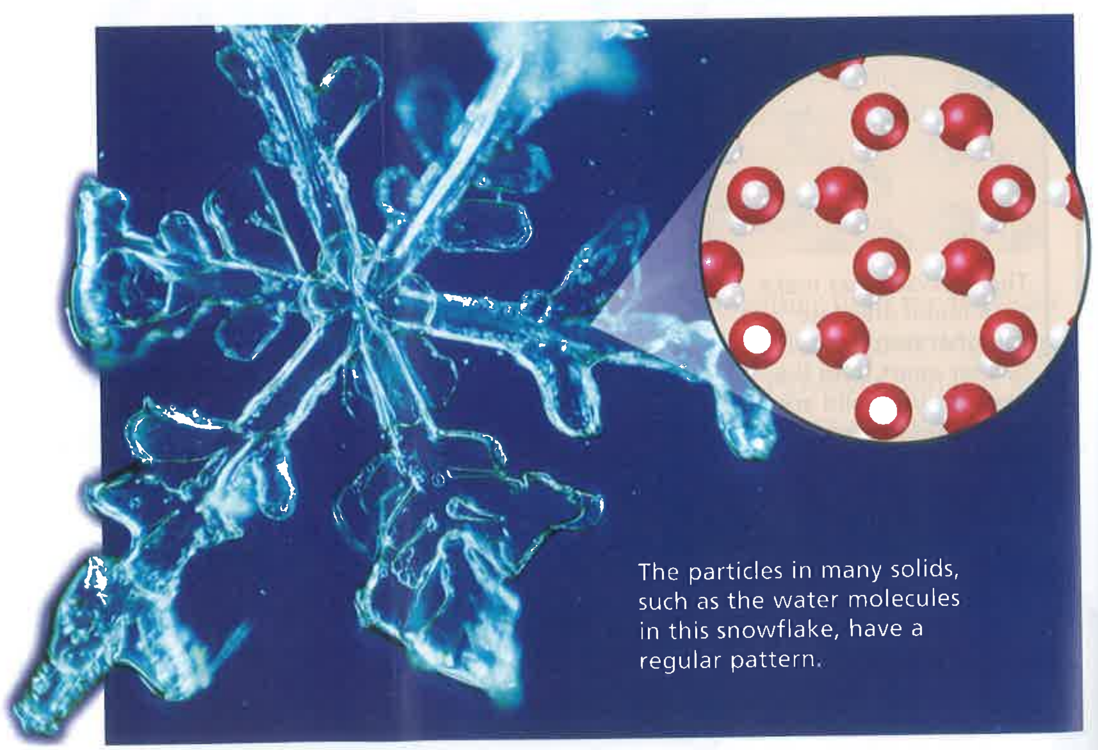
Solids have a definite volume and shape.

REMINDER
Volume is the amount of space that an object occupies.

A piece of ice, a block of wood, and a ceramic cup are solids. They have shapes that do not change and volumes that can be measured. Any matter that is a solid has a definite shape and a definite volume.

The molecules in a solid are in fixed positions and are close together. Although the molecules can still vibrate, they cannot move from one part of the solid to another part. As a result, a solid does not easily change its shape or its volume. If you force the molecules apart, you can change the shape and the volume of a solid by breaking it into pieces. However, each of those pieces will still be a solid and have its own particular shape and volume.

The particles in some solids, such as ice or table salt, occur in a very regular pattern. The pattern of the water molecules in ice, for example, can be seen when you look at a snowflake like the one shown below. The water molecules in a snowflake are arranged in hexagonal shapes that are layered on top of one another. Because the molecular pattern has six sides, snowflakes form with six sides or six points. Salt also has a regular structure, although it takes a different shape.

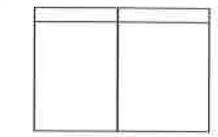

The particles in many solids, such as the water molecules in this snowflake, have a regular pattern.

Not all solids have regular shapes in the same way that ice and salt do, however. Some solids, such as plastic or glass, have particles that are not arranged in a regular pattern.

CHECK YOUR READING What two characteristics are needed for a substance to be a solid?

Liquids have a definite volume but no definite shape.

MAIN IDEA AND DETAILS
As you read, organize the headings and details in a two-column chart.



Water, milk, and oil are liquids. A liquid has a definite volume but does not have a definite shape. The volume of a certain amount of oil can be measured, but the shape that the oil takes depends on what container it is in. If the oil is in a tall, thin container, it has a tall, thin shape. If it is in a short, wide container, it has a short, wide shape. Liquids take the shape of their containers.

The molecules in a liquid are close together, but they are not tightly attached to one another as the molecules in a solid are. Instead, molecules in liquids can move independently. As a result, liquids can flow. Instead of having a rigid form, the molecules in a liquid move and fill the bottom of the container they are in.

CHECK YOUR READING How is a liquid different from a solid?

INVESTIGATE Liquids

How do different liquids behave?

PROCEDURE

1. Using the graduated cylinder, measure 5 mL of colored water. Add it to the test tube.
2. Measure 5 mL of vegetable oil. Pour the oil into the test tube. Record your observations.
3. Pour a small amount of corn syrup directly into the test tube. Record what happens to all three liquids.
4. Add 10 mL more of colored water to the test tube and record what happens.
5. Add 5 mL more of vegetable oil and record what happens.

WHAT DO YOU THINK?

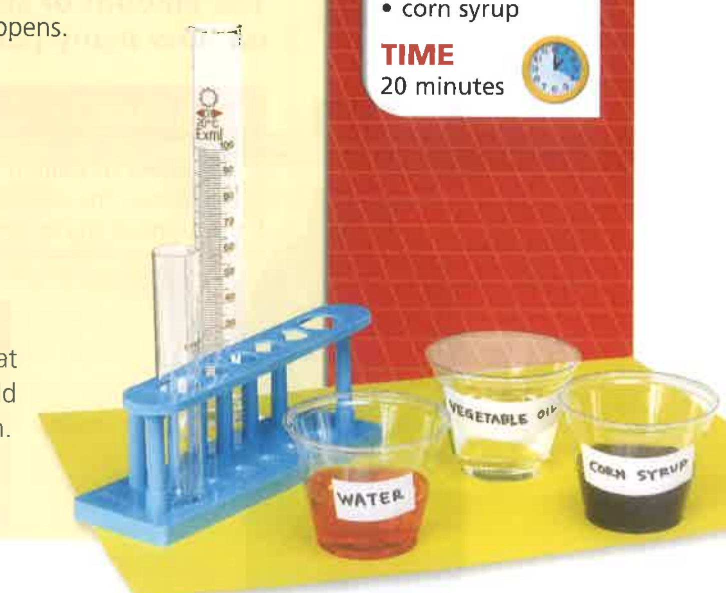
- How did the layers change as more liquid was added?
- What are some behaviors of each of the liquids in this experiment that can be used to tell them apart?
- What would happen if you changed the order in which you added the liquids?

CHALLENGE Think of a liquid you are familiar with that was not used in this experiment. What do you think would happen if you added that liquid to your test tube? Explain.

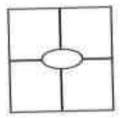
SKILL FOCUS
Measuring

MATERIALS
- graduated cylinder
- colored water
- test tube
- test-tube rack
- vegetable oil
- corn syrup

TIME
20 minutes



VOCABULARY
Add a four square diagram to your notebook for *gas*.



Gases have no definite volume or shape.

The air that you breathe, the helium in a balloon, and the neon inside the tube in a neon light are gases. A gas is a substance with no definite volume and no definite shape. Solids and liquids have volumes that do not change easily. If you have a container filled with one liter of a liquid that you pour into a two-liter container, the liquid will occupy only half of the new container. A gas, on the other hand, has a volume that changes to match the volume of its container.

Gas Composition

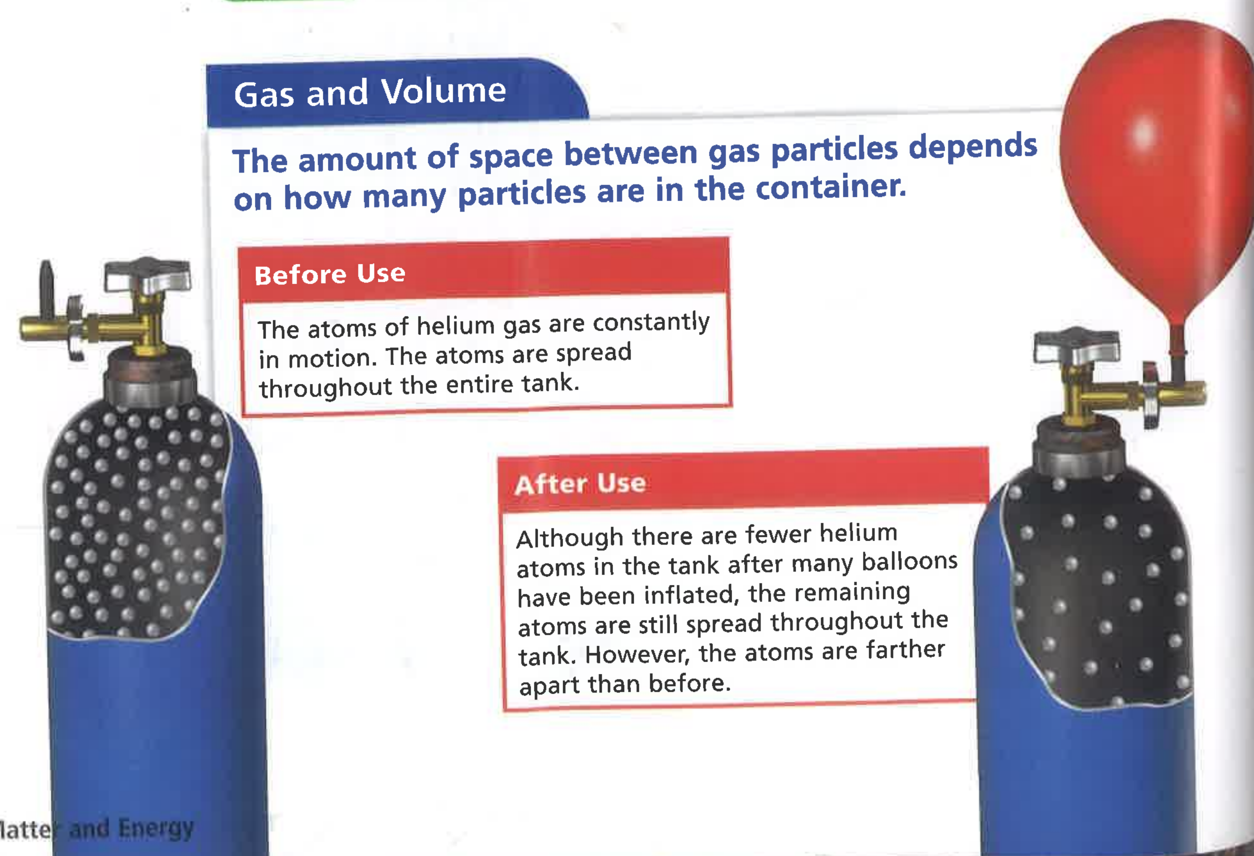
The molecules in a gas are very far apart compared with the molecules in a solid or a liquid. The amount of space between the molecules in a gas can change easily. If a rigid container—one that cannot change its shape—has a certain amount of air and more air is pumped in, the volume of the gas does not change. However, there is less space between the molecules than there was before. If the container is opened, the molecules spread out and mix with the air in the atmosphere.

As you saw, gas molecules in a container can be compared to a group of people in a room. If the room is small, there is less space between people. If the room is large, people can spread out so that there is more space between them. When people leave the room, they go in all different directions and mix with all of the other people in the surrounding area.

CHECK YOUR READING Contrast the molecules in a gas with those of a liquid and a solid.

Gas and Volume

The amount of space between gas particles depends on how many particles are in the container.



Gas Behavior

SIMULATION CLASSZONE.COM
Explore the behavior of a gas.

Because gas molecules are always in motion, they are continually hitting one another and the sides of any container they may be in. As the molecules bounce off one another and the surfaces of the container, they apply a pressure against the container. You can feel the effects of gas pressure if you pump air into a bicycle tire. The more air you put into the tire, the harder it feels because more gas molecules are pressing the tire outward.

The speed at which gas molecules move depends on the temperature of the gas. Gas molecules move faster at higher temperatures than at lower temperatures. The volume, pressure, and temperature of a gas are related to one another, and changing one can change the others.

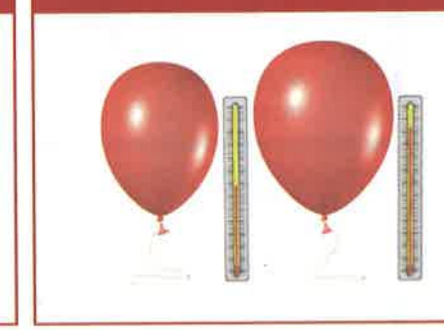
Pressure ▲ Volume ▼ Temp. ■

If the temperature of a gas stays the same, increasing the pressure of the gas decreases its volume.

Pressure ▲ Volume ■ Temp. ▲

If the volume of a gas stays the same, increasing the temperature of the gas also increases the pressure.

Pressure ■ Volume ▲ Temp. ▲



If the pressure of a gas stays the same, increasing the temperature of the gas also increases the volume.

In nature, volume, pressure, and temperature may all be changing at the same time. By studying how gas behaves when one property is kept constant, scientists can predict how gas will behave when all three properties change.

1.4 Review

KEY CONCEPTS

1. What are the characteristics of the three familiar states of matter?
2. How can you change the shape and volume of a liquid?
3. How does gas behave inside a closed container?

CRITICAL THINKING

4. **Infer** What happens to a liquid that is not in a container?
5. **Synthesize** What is the relationship between the temperature and the volume of a gas?

CHALLENGE

6. **Synthesize** Can an oxygen canister ever be half empty? Explain.